ALASKA OREGON WASHINGTON
PACIFIC NORTH WEST FOREST AND RANGE EXPERIMENT STATION

USDA FOREST SERVICE RESEARCH NOTE

PNW-188 September 1972

AN INEXPENSIVE WATER SAMPLER

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Abstract

A stream sampler with no exterior energy requirements or moving parts has been designed and tested. A basic model has been described that has many options to fit particular sampling needs. Basic cost of the unit, excluding sampler mounting and structures needed to provide stream control, is less than $10.

Keywords: *Water analysis, sample designs (forestry), Poiseuille's Law, streams.*

FOREST SERVICE - U.S. DEPARTMENT OF AGRICULTURE - PORTLAND, OREGON

INTRODUCTION

Increasing interest in maintaining the high standards of water quality in our forest streams has precipitated development and installation of a number of efficient stream water monitoring systems.[1/] [2/] Due to complexity and power requirements or both, these systems are not readily adaptable for monitoring in remote areas nor capable of simple and rapid installation.

Although samplers may be used in a variety of situations, several common requirements appear. These include:

(1) definable sample rate, either at a constant volume or proportional to changing stream head,
(2) dynamic sampling, i.e., no material maintained in an extended static presample status,
(3) freedom from inlet blockage, especially at low sampling rates.

Operation in remote locations requires additionally:

(4) minimal or no electrical power requirements,
(5) minimum of mechanical components,
(6) insensitivity to temperature changes,
(7) low cost.

A sampler meeting these requirements has been designed and field tested.

DESIGN

The collection rate selected for this sampler is between 0.1 and 20.0 cubic centimeters per minute. This rate is a direct function of the hydraulic head above the sample intake and rate of air released from the sample collection bottle. Hydraulic heads of less than 1 meter are desirable for operation of the sampler.

1/ *R. L. Fredriksen. A battery-powered proportional stream water sampler. Water Resour. Res. 5(6): 1410-1413, 1969.*

2/ *Robert D. Doty. A portable, automatic water sampler. Water Resour. Res. 6(6): 1787-1788, 1970.*

The basic system as shown in figure 1 consists of the following:

(1) 20-liter polyethylene carboy;
(2) rubber stopper;
(3) two glass tubes, 6-centimeter length, 3-millimeter inside diameter;
(4) flexible tubing; and
(5) small diameter capillary.

The carboy is submerged to the desired depth. Water enters the carboy through the 3-millimeter inside diameter glass tube. This tube is large enough to minimize clogging by suspended material, yet small enough to prevent water inflow by capillary action. For water to enter the airtight carboy, an equal volume of air must be released. The sampling rate for a given waterhead is dictated by a small diameter capillary, which is inserted at the end of the exhaust tube. Increasing the waterhead on the intake tube increases the carboy air pressure and, consequently, increases the air outflow and water inflow. The outlet airflow can be calculated from Poiseuille's Law for viscous flow of liquids (also air) through a tube. Given ℓ as the length of the tube in centimeters, r its radius in centimeters, p the difference of pressure along the tube in dynes per square centimeter, and η the coefficient of viscosity in poises or dynes second per square centimeter (the value for air at 20° C. is 1.82×10^{-4} poise), the volume of air escaping in cubic centimeters per second will be:

$$V = \frac{\pi p r^4}{8 \ell \eta}. \qquad (1)$$

The pressure head is the hydraulic head (1 cm. water = 1,000 dynes/cm.^{2}) at the outlet or lower end of the intake tube. Figure 2 shows the sample volume-hydraulic head relationship for a sampler controlled by one useful size of capillary (5.08-cm. (2-inch) 33-gage hypodermic needle).

The advantage that accrues from capillary control of the air at the outlet rather than water at the inlet is principally due to cleanliness of the displaced air and air's predictable flow characteristics through small orifices.

The sampler must be located at a stream control, natural or artificial, for sampling at a rate proportional to streamhead. A relationship between streamhead and streamflow would be required to determine total material carried by the stream. On small streams

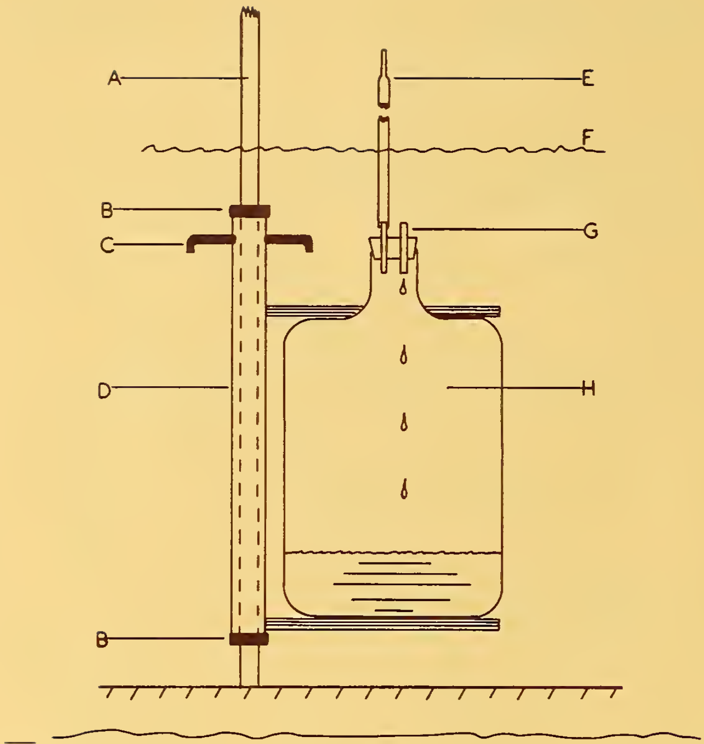

Figure 1.--Proportional water sampler: *A*, Stand pipe; *B*, position hold collars; *C*, position control handles; *D*, sampler support carriage; *E*, air pressure control capillary; *F*, stream surface; *G*, sample inlet; *H*, carboy. Elevation difference between the stream surface (*F*) and the bottom of the sample inlet tube (*G*) equals hydraulic head.

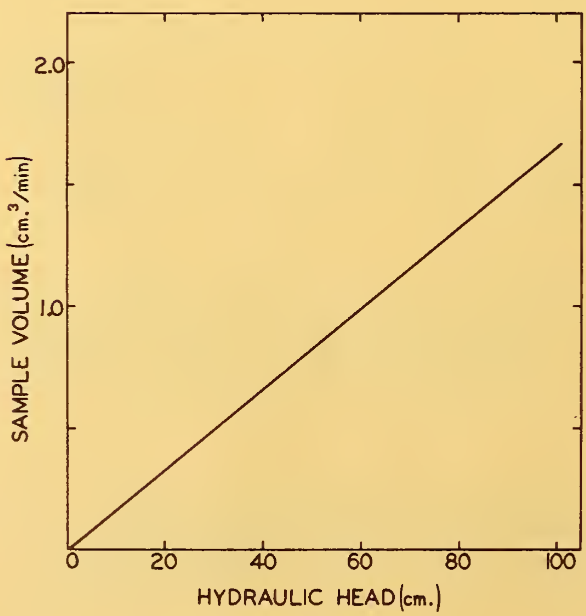

Figure 2.--Sample volume-hydraulic head relationship for a control capillary 5.08 cm (2 inches) long and 0.508 mm (0.002 inch) radius.

a control can easily be provided with a temporary weir. If the relationship between head and streamflow volume is not needed, a small rock dam or several wooden planks would be adequate. A number of modifications of the basic sampling system can be made to fit the particular sampling need and location.

The sampler is easily protected from climatic extremes. For some nutrient studies the collected samples should be kept at stream temperatures. Keeping the carboy in the stream provides this temperature control.

The sampler is calibrated in the laboratory. The stopper with its inlet tube and air release capillary is placed over a graduated cylinder. Varying the hydraulic head produces corresponding sample volumes per unit time in the graduated cylinder. These measurements provide the basis for a calibration similar to that shown in figure 2. The graduated cylinder or the collection vessel must be pressurized to equal the hydraulic head before initiating sampling. A rubber squeeze bulb temporarily connected to the collection bottle is used for this purpose.

Samplers are currently being used on three forest streams in north-central Washington. Two models are being used. The first is a continuous sampler as described above; the second, an intermittent sampler. The intermittent sampler uses a larger air release capillary (22-gage) and a solenoid valve in the air release line. This valve is periodically activated by a recorder mechanism and allows a volume of air to escape from the sample collection bottle. The capillary is required to prevent complete loss of pressure and unequal sample volumes as the collection bottle fills. No detectable difference between the two methods has been found in the water sample.

This sampler is incapable of adequate sampling of suspended sediments. Orifice diameter and flow rates are below required minimums.[3/] Any material carried by the input flow, however, is collected and represents some (unknown) fraction of the suspended load. This sample may be of some qualitative aid in evaluating sediment production from adjacent streams.

[3/] *St. Anthony Falls Hydraulic Laboratory. A study of methods used in measurement and analysis of sediment loads in streams. Minneapolis, Minn., Fed. Interagency Sedimentation Proj., Laboratory Investigation of Pumping Sampler Intakes, Rep. T, 1966.*

Reviewers pointed out three concerns with the sampler. One concern is that a 3-millimeter-diameter intake may clog in some streams. We have not experienced this difficulty. Quite possibly screens could be used to prevent clogging. Second, the horizontal stream velocity over the sampler intake tube was not taken into account in assuming a straight-line relationship between hydraulic head and sampling rate. Behind stream controls used for flow measurement, horizontal stream velocity is not recommended to exceed 0.5 foot per second.[4/] A 0.5-foot-per-second horizontal stream velocity across the intake tube would cause a water pressure head decrease of 0.1184 centimeter or a decrease in sampling rate of approximately 0.0013 cubic centimeter per minute. Higher velocities would cause larger error, but we believe this effect is negligible and need not be considered. Earlier we have pointed out that the sampling rate is proportional to streamhead. The sampling rate is proportional to stream volume only under conditions where water volume passing the stream control is proportional to streamhead.

[4/] *Orson W. Israelsen and Vaughn E. Hansen. Irrigation principles and practices. New York, John Wiley & Sons, 447 p., 1962.*

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